

Claims

What is claimed is:

- 1 **1.** A fuel cell power plant (10) for generating
2 electrical energy from a process oxidant stream (53,
3 42, 28) and a reducing fluid stream (26), the plant
4 comprising:
 - 5 a) at least one fuel cell (12) for producing the
6 electrical energy from the process oxidant stream (53,
7 28) and the reducing fluid stream (26), and providing
8 a fuel cell exhaust stream (48) containing moisture
9 and sensible heat;
 - 10 b) an energy recovery device (32) having first and
11 second gas flow channels (44, 42) separated by a
12 respective enthalpy exchange barrier (46), the fuel
13 cell exhaust stream (48) connected to pass through the
14 first gas flow channel (44) and a source of process
15 oxidant (30) for the process oxidant stream (53)
16 connected to pass through the second gas flow channel
17 (42), thereby to allow mass and heat transfer between
18 the gases in the first and second gas flow channels via
19 the enthalpy exchange barrier; and
 - 20 c) injection means (58, 60) disposed to inject
21 a liquid medium (66, 64) into the process oxidant
22 stream (53) preparatory to the process oxidant passing
23 through the energy recovery device second gas flow
24 channel (42) for regulating the transfer of mass and
25 heat between the fuel cell exhaust stream (48) and the
26 process oxidant stream (53, 42).
- 1 **2.** The fuel cell power plant (10) of claim 1 wherein
2 the energy recovery device includes an inlet (54) for
3 receiving the process oxidant stream (53) to pass
4 through the second gas flow channel (42), the liquid
5 medium for injection is water, and the injection means
6 (58, 60) is positioned to inject the water into the

7 process oxidant stream (53) immediately upstream of
8 said inlet (54).

1 **3.** The fuel cell power plant (10) of claim **2** including
2 a plenum (62) located immediately upstream of said
3 inlet (54), said process oxidant stream (53) flows
4 through said plenum (62), and wherein the injection
5 means (58, 60) is operative to inject water (66, 64)
6 into the plenum (62) for intimate mixing with and
7 humidification of the process oxidant stream.

1 **4.** The fuel cell power plant of claim **2** wherein the
2 injection means comprises one or more spray nozzles
3 (60) disposed to inject a spray of water (66, 64) into
4 the plenum (62).

1 **5.** The fuel cell power plant (10) of claim **3** wherein
2 the injection means comprises one or more spray nozzles
3 (60) disposed to inject a spray of water (66, 64) into
4 the plenum (62).

1 **6.** The fuel cell power plant (10) of claim **1** including
2 control means (70, 74, 78, 80, 84) operatively
3 associated with the injection means (58, 60) for
4 controlling at least the amount of the liquid
5 medium (66, 64) being injected.

1 **7.** The fuel cell power plant (10) of claim **6** wherein
2 the control means (70, 74, 78, 80, 84) include at least
3 one or the other of a temperature sensor (80) for
4 sensing the temperature of ambient process oxidant and
5 a humidity sensor (84) for sensing the moisture content
6 of the ambient process oxidant.

1 **8.** The fuel cell power plant (10) of claim **7** wherein
2 the control means (70, 74, 78, 80, 84) includes both

3 the temperature sensor (80) and the humidity sensor
4 (84).

1 **9.** The fuel cell power plant (10) of claim 1 wherein
2 the enthalpy exchange barrier (46) of the energy
3 recovery device (32) comprises a fine-pore support
4 matrix.

1 **10.** The fuel cell power plant (10) of claim 9 wherein
2 the fine-pore support matrix is one or a combination
3 selected from the group consisting of porous graphite
4 layers; porous graphite-polymer layers, inorganic-fiber
5 thermoset polymer layers, glass fiber layers,
6 synthetic-fiber filter papers treated to be wettable,
7 porous metal layers, and perforated metal layers with
8 particulate material in the pores.

1 **11.** In a fuel cell power plant (10) for generating
2 electrical energy from a process oxidant stream (53,
3 42, 28) and a reducing fluid stream (26), the plant
4 comprising a fuel cell (12) for producing the
5 electrical energy from the process oxidant stream (53,
6 28) and the reducing fluid stream (26), and providing
7 a fuel cell exhaust stream (48) containing moisture
8 and sensible heat; and an energy recovery device (32)
9 having first and second gas flow channels (44, 42)
10 separated by a respective enthalpy exchange barrier
11 (46), the fuel cell exhaust stream (48) connected to
12 pass through the first gas flow channel (44) and a
13 source of process oxidant (30) for the process oxidant
14 stream (53) connected to pass through the second gas
15 flow channel (42), thereby to allow mass and heat
16 transfer between the gases in the first and second gas
17 flow channels via the enthalpy exchange barrier, the
18 method comprising:
19 dispensing water (66, 70, 74, 60, 64) into the

20 process oxidant stream (53) preparatory to the process
21 oxidant passing through the energy recovery device
22 second gas flow channel (42) for regulating the
23 transfer of mass and heat between the fuel cell
24 exhaust stream (48) and the process oxidant stream
25 (53, 42).

1 **12.** The method of claim **11** wherein the step of
2 dispensing water (66, 70, 74, 60, 64) into the process
3 oxidant stream (53) comprises monitoring (80, 84, 90)
4 one or more parameters of the fuel cell power plant
5 (10), including the process oxidant stream (53, 42,
6 28), and controllably injecting water into the process
7 oxidant stream (53) in response to the one or more of
8 the monitored parameters.

1 **13.** The method of claim **12** comprising the steps of
2 monitoring (80) the temperature of the process oxidant
3 stream (53), and injecting water (66, 70, 74, 60, 64)
4 into the process oxidant stream when the temperature
5 exceeds a threshold, thereby to cool and humidify the
6 process oxidant stream (53, 42) to inhibit dry-out of
7 the enthalpy exchange barrier 46 in the energy
8 recovery device 32.

1 **14.** The method of claim **13** wherein the temperature
2 threshold is in the range of about 85⁰ to 90⁰ F.

1 **15.** The method of claim **12** wherein the operating status
2 of the power plant (10) is monitored (70, 80) to
3 identify the condition of start-up, and injecting
4 water (66, 70, 74, 60, 64) into the process oxidant
5 stream upon start-up, at least after a shutdown
6 exceeding a predetermined duration, for assuring
7 sufficient wetting of the enthalpy exchange barrier
8 (46) during start-up.

1 **16.** The method of claim **15** wherein a temperature of the
2 power plant (10), including the inlet temperature of
3 the process oxidant stream (53, 42, 28), is monitored
4 (80) to detect a freezing condition, and controllably
5 (70, 78) injecting heated water (66, 58, 60, 64) during
6 start-up in response to detection of a freezing
7 condition to defrost at least the energy recovery
8 device 32.

1 **17.** The method of claim **12** wherein the fuel cell power
2 plant (10) includes a coolant system (38, 88), and
3 including the steps of monitoring (90) the level of
4 coolant in the coolant system (38, 88) and injecting
5 water (66, 58, 70, 74, 78, 60, 64) into the process
6 oxidant stream when the coolant level exceeds a
7 threshold, thereby to raise the dew point of the
8 process oxidant stream (53, 42) to inhibit recovery of
9 water from the fuel cell exhaust stream 48 via the
10 enthalpy exchange barrier 46 to the process oxidant
11 stream (42).